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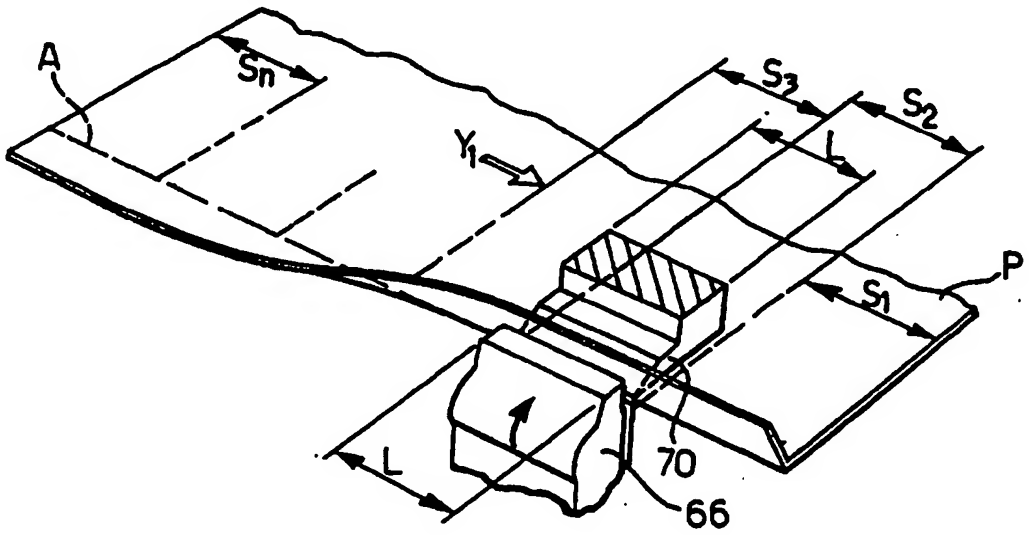

(57) Abstract

In order to bend an edge of a panel (P), use is made of a blade (66) and a counterblade (70) whose length (L) is less than the length of the bend to be formed. The bend is formed by causing the blade and counterblade and the panel to execute a relative movement in a series of steps along the bend line (A).

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Method and machine for the production of sheet metal panels

The present invention relates to a method and to a machine for the production of sheet metal panels with at least one bent edge, in which the bend or bends in the panel are formed by means of a bending unit having as a minimum, by way of tools, a pair of opposing blankholders and at least one blade and one counterblade which cooperate to define a bend line, in which the panel to be bent is gripped and moved by gripping means forming part of a manipulator provided for the unit and in which, in order to form bends, the relative movements of the tools and of the gripping and moving means are controlled in a coordinated way in order to form one or more programmed bends in the panel.

Methods and machines of this kind are known from a great many prior documents. Examples of documents that may be cited include CH-A-216 009, US-A-2 734 552, US-A-3 058 512, US-A-4 242 898, EP-A-0 027 122, EP-A-0 077 314 and EP-A-0 298 056.

In all these documents the bending is performed on presses in which the blades and counterblades are longer than the maximum length of the edge which the press is designed to bend. This means that for most of the time the press is being used at below capacity: it is not uncommon, for example, for a press having two-metre long bending blades and counterblades to be used to bend the edges of metal sheets whose longest side measures much less than one metre.

On the other hand, a panel manufacturer may find himself in a situation in which he is required to fabricate panels with bent edges whose sides are longer than the blades and counterblades of his presses. This means that even though such work may be infrequent, he is obliged to install a press of greater capacity than the presses he

uses in normal production, or else to turn such work away.

The main object of the present invention is to provide a method and a machine of the type discussed above which will make it possible to fabricate, on a single low-cost piece of equipment of small dimensions, panels with bent edges of indefinite length, varying for example from a few centimetres to more than two metres, preferably with numerical control over the panel bending and manipulating operations.

According to the present invention, this object is achieved by means of a method and a machine as claimed.

The essence of the invention lies in its use of a bending unit having at least one blade and one counterblade of short length, e.g. a few centimetres, and in forming a bend in successive steps or lengths, by for example moving the panel in steps along the bending unit, or alternatively holding the panel still and moving the unit in steps along the bend line. All the relative movements of the tools and of the metal panel gripping means lend themselves to numerical control, which means that fully automated, highly versatile machine cycles can be obtained.

In a preferred embodiment of the invention, the bending unit can be mounted in a punch press containing many selectively-controlled punches, by first simply replacing one punch and its die with two opposing tool-holder blocks, one of which is movable and the other fixed, and using, in combination with the press, panel gripping and moving means in the form of a manipulator having one or more panel gripping clamps.

A clearer understanding of the invention will be obtained by reading the following description, which refers to the accompanying drawings serving for non-restricting illustrative purposes, in which drawings:

Figure 1 is a schematic perspective view of a machine for the production of sheet metal panels with bent edges

according to the invention,

Figure 2 is a longitudinal section through the machine on the plane marked II-II in Figure 1,

Figure 3 is a plan view of the same, partially sectioned on the horizontal plane marked III-III in Figure 1,

Figure 4 is a partial schematic detail perspective view, partially sectioned, of the machine shown in Figures 1 to 3,

Figures 5 and 6 are partially sectioned elevational views of an example of a bending unit forming part of the machine in a rest condition in Figure 5 and in a working condition in Figure 6,

Figure 7 is a partial perspective view of a blade used in the unit of Figures 5 and 6,

Figures 8 and 9 are schematic perspective views illustrating two different steps in a cycle of bending one edge of a sheet metal panel,

Figures 10 to 13 are schematic top views illustrating an example of a cycle of bending the edges of rectangular panels, and

Figures 14 to 35 are schematic plan views illustrating another example of a cycle of bending the external and internal edges of a slotted panel.

The accompanying drawings illustrate a machine and a method using a punch press that has been modified to carry out bending according to the invention, but it will be understood that the invention is applicable to other machines comprising a bending unit and a manipulator linked to this unit.

Likewise, although the drawings illustrate an embodiment in which the bends are formed as the panel moves while the bending unit remains stationary, the invention is equally applicable to any kind of relative movement between a panel and a bending unit.

Although the drawings and the associated description only relate to the case in which the panels are horizontal and the machine works on them by means of vertical movements, the invention is applicable independently of the orientations of the moving parts and of the directions in which they move in space.

With reference to Figures 1 to 3, a machine comprises a rugged, fixed, basically C-shaped frame 10 with two opposing parts integral with each other and spaced from each other. One of these two parts is a larger lower arm 12, while the other is a smaller upper arm 14.

The lower part 12 acts as a bed for a manipulator bearing the general reference 16.

The manipulator 16 comprises a horizontal table 18, for example of the known ball type. The table 18 is for supporting sheet metal panels, which are not shown in Figures 1 to 3, during the operations of loading and unloading the machine as well as during bending operations in the machine itself.

Along the bed 12 and on the sides of the table 18 there extends a pair of longitudinal ways 20 along which there can move a first slide 22 in the form of a cross member arranged in the manner of a bridge over the table 18.

The slide 22 can be moved towards and away from the upper arm 14 as indicated by the double arrow X in Figures 1 and 3.

A second slide 24 can be moved backwards and forwards along the cross member constituting the first slide 22, as indicated by the double arrow Y (Figures 1 and 3), perpendicular to the direction X.

The orientation of directions X and Y will be further discussed later.

The two slides 22 and 24 are each moved by their own screw-and-nut-type motorized drives, the screws of which

are marked 26 and 28 respectively. Each screw 26 and 28 can be rotated by its own numerical-control motor 30, 32.

The second slide 24 carries a pair of clamps 34.

The clamps 34 are of a well-known type with controlled opening and closing and, as will be seen more clearly below, they serve to grip the sheet metal panels along their edges and thus act as means for gripping and moving the panels with respect to a bending unit which will shortly be described.

Still with reference to Figures 1 to 3, the lower part 12 and the upper part 14 of the frame 10 each support a respective turret 36, 38. The two turrets 36, 38 are spaced from each other and are rotatable as one about a common vertical axis Z_1 normal to the horizontal planes defined by the table 18 and by the two directions X and Y, and therefore normal to the general plane of the panels undergoing bending.

For the purpose of their coupled rotation, the two turrets 36 and 38 receive their motion from a common drive shaft 40 via respective timing belts 42. The shaft 40 receives its motion from a motor 44, preferably of the stepping type.

The two turrets 36 and 38 are of the familiar type used in multiple-punch presses.

In a known manner, each of the turrets 36, 38 has a ring of seats each aligned with the seats of the other turret in a circle C (Figure 3) concentric with the axis of rotation Z_1. In the pairs of aligned seats, or in at least some of these, one seat contains a lower die 46 and the other a cooperating upper punch 48.

In a known manner, the upper part 14 of the frame 10, which supports the upper turret 38 containing the punches 48, supports a ram 50. The ram 50 can be moved along an axis Z_2, parallel with the axis Z_1, by the piston 52 of a hydraulic or pneumatic cylinder 54.

The ram 50 is in the nearest position to the table 18 and actuates, in a known manner, whichever punch 48 has been moved by the indexed turning of the turrets 36 and 38 into position underneath the ram.

According to the invention, there is fitted in a pair of aligned seats on the two turrets 36 and 38 a bending unit bearing the general reference 54.

The unit 54 will now be described in greater detail with reference to Figures 4 to 6.

The structure formed by the two turrets 36 and 38 supports two opposing toolholder blocks, namely a lower block 56 and an upper block 58.

The block 56 is fixed in its cup-like seat 60, which in turn can rotate in the lower turret 36.

The upper block 58 is mounted in a seat in the form of a sleeve 62, which in turn can rotate in the upper turret 38.

Incorporated in the lower block 56 are a lower blankholder 64 and a bending blade 66.

The upper block 58 has on its underside a projection 68 resembling a boot which acts as a blankholder and has a projection 70 acting as the counterblade.

The arrangement is such that when the upper block 58 is underneath the ram 50, downward movement of the latter causes the block 58 to descend inside its seat 62.

The descent of the block 58 has the effect of clamping a panel P between the two blankholders 68 and 64, as illustrated in Figures 5 and 6. The continued descent of the upper blankholder 68 drives down the lower blankholder 64 which, through a lever 72 incorporated in the lower block 56, lifts the blade 66, causing a bend to be formed as illustrated in Figure 6. The movements of the upper block 58, lower blankholder 64 and blade 66 are opposed by a spring 74 whose function is to return the system from the condition of Figure 6 to that of Figure 5 when the ram 50

ceases to act on the upper block 58.

Figure 6 shows an extreme position in which the blade 66 has formed a right-angled bend in the panel P, but by controlling the descent of the upper toolholder block 58 in a programmed manner, for example by numerical control, it is possible to obtain bends of any angle and in particular, as will be described later, angles which are approached gradually.

The tooling system of the two blocks 56 and 58 illustrated in Figures 4 to 6 is only an example. Special tooling systems are disclosed and illustrated in two patent applications filed on even date by the same Applicant, both having the title "Bending apparatus for metal sheets".

As has already been stated earlier the two blocks 56 and 58 are able to rotate in their respective turrets 36 and 38. For their rotation, the two blocks 56, 58 are motor-driven and indexed as one about a vertical axis Z_2 parallel with the axis Z_1 and therefore normal to the plane of the panels P to be bent which can be seen in Figure 4. For the rotary driving of the blocks 56, 58, each block is connected to its own numerical-control stepping motor 76, 78, which rotates its corresponding block through a respective timing belt 80, 82.

As will be understood more clearly further on, the two motors 76, 78 index the two blocks 56, 58 as one about the axis Z_2 for the purpose of executing bends either on lines parallel with the axes X and Y, or along bend lines not parallel with these axes.

A preferred feature, illustrated in Figure 7, is that the active edge, marked 84, of the blade 66 is beveled at each end 86. The purpose of these beveled ends 86 will be explained later in the description of Figures 8 and 9.

In Figure 8, B indicates the straight bend line defined by the active edges of the blade 66 and counter-blade 70.

According to the invention, the blade 66 and counterblade 70 have a length L less than the length of the bend or bends to be formed along a line A. By way of example, the length L may be 10 cm, while the length of a bend along A, that is of one side of a panel P, may be more than one metre.

In order to form a bend, the movements of the blades and the relative movements of the unit 54 and gripping means 34 (clamps or the like) of the manipulator 16 are brought about in a coordinated way by a numerical-control system or the like in order to execute a bending cycle.

A preferred embodiment of this cycle will be described with reference to Figures 8 and 9.

The blade 66 and counterblade 70 are initially at the right-hand limit of Figure 8 and form the bend of a first part S_1 of the edge of the panel P.

After the part S_1 has been bent, following the moving apart of the blankholders 64, 70 the clamps 34 move the panel P one step in the direction of arrow Y_1, after which the blankholders come together again to grip the panel P and the blade 66, cooperating with the counterblade 70, forms the bend of a second part S_2.

Bending then continues on successive parts S_3 ... S_n, as far as the left-hand end in Figure 8.

Moving from one part S_1, S_2 ... to the next is facilitated by the corresponding bevel 86 which is on the forward side with respect to the direction of relative movement of the tools 66, 70 and panel P.

The angle of the bend formed by the procedure illustrated in Figure 8 may be smaller than desired.

When the tools 66, 70 have reached the end of their relative travel, on the left of Figure 8, the same procedure of bending in successive steps may be resumed in the other direction, moving the panel P by means of the clamps 34 in the reverse direction as indicated by the

arrow Y_2 in Figure 9, until the tools have returned to the relative position situated on the right-hand end of this figure.

At this point the bend may have been completed with the desired angle.

Moving from one part of the bend to the next in the case of Figure 9 is facilitated by the other bevel 86 which is on the forward side with respect to the relative movement of the tools 66, 70 and panel P.

The operations shown in Figures 8 and 9 are repeated as many times as is necessary to achieve the final bend angle.

One possible method for bending the four sides of a rectangular panel will now be described with reference to Figures 10 to 13.

In Figures 10 to 13, parts that have already been described and illustrated in the earlier figures are indicated by the same reference numerals.

In Figures 10 to 13, S denotes a metal sheet, inside the outline of which there are two panels P_1 and P_2 which are to be bent.

On a different machine from that illustrated in the preceding figures, the metal sheet S is first put through a cutting operation in order to form, inside the outline of the sheet S, cut preforms of a shape corresponding to that of the panels P_1 and P_2 to be bent. In this cutting operation, bridges of metal B are left connecting the outline of the sheet S to the corners, or to at least some of these corners.

Figures 10 to 13 will now be referred to in order to describe a bending cycle, reference also being made to Figures 5 and 6, as regards the tools used in the cycle.
I - Before the condition shown in Figure 10 is reached, while the blankholders 64, 68 are held apart from each other and the blade 66 and counterblade 70 are inactive,

the sheet S is held by the clamps 34 and moved to the position shown in Figure 10 in which a first edge E_1 of the panel P_1 is between the tools. In this way the line of the bend to be formed corresponds to the abovementioned bend line A (Figure 8) and the tools are situated on either side of an initial part of the edge E_1.

II - At this point the panel P_1 is clamped between the two blankholders 64, 68 and the blade 66 and counterblade 70 form a first part of the bend while the panel P_1 is stationary with respect to the unit 54.

III - After the first part of the bend has been formed, the two blankholders 64, 70 are moved away from each other and the clamps 34 move the sheet S, with the panel P_1, towards the right in Figure 10, for a distance approximately equal to or slightly less than the length L (Figure 8) of the blade and of the counterblade.

IV - Once the position corresponding to the second part (S_2 - Figure 8) has been reached, the panel P_1 is clamped between the two blankholders 64, 68 and the next part of the bend corresponding to S_2 is formed by the blade 66 and counterblade 70.

V - Steps III and IV are repeated as many times as is necessary to continue the bend as far as the final end of the edge E_1 (on the right in Figure 10).

After this, if the bend formed in the manner described above is not complete, for example it has not achieved a desired dihedral angle of 90°, similar steps are carried out with a relative movement of the sheet S and of its panel P_1 in the reverse direction as far as the abovementioned initial part (the condition shown in Figure 10). If the desired angle has not yet been achieved, more such steps are carried out in one direction or the other, as shown by the double arrow Y in Figures 1, 3 and 4, as many times as is necessary to achieve the desired final angle.

Once the edge E_1 is fully bent, and after the blankholders 64 and 68 have been relaxed, the clamps 34 move the sheet S in such a way as to bring the unit 54 to the position shown in Figure 11, the latter in the meantime having rotated through 90° in order to execute the bending of edge E_2 in the same way as described above.

During the bending of the edge E_2, the sheet S is moved stepwise by the clamps 34 in the direction X of Figures 1, 3 and 4.

Once the second edge E_2 has been bent as in Figure 11, the sheet S is again moved by the clamps 34 to bring the unit 54 onto the third edge E_3. The bending of the edge E_3 then takes place, in the manner described, with stepwise movements of the sheet S forwards and backwards along the double arrow Y of Figures 1, 3 and 4.

The fourth edge E_4 is bent by a similar procedure to that described above, with the sheet S being moved by the clamps as far as the position shown in Figure 13, followed by stepwise movement of the sheet S backwards and forwards in the direction of the double arrow X of Figures 1, 3 and 4.

Once the bending of all four edges E_1, E_2, E_3, E_4 of the panel P_1 has been completed, the clamps 34 move the sheet S to bring the second panel P_2 into the position corresponding to that of the panel P_1 in Figure 10. The bending of the four edges of the second panel P_2 is then performed in the manner described above.

The separation of the two panels P_1 and P_2 from the remainder of the sheet S is done later by breaking or removing the bridges B.

Clearly, a sheet such as S could contain more than two precut panels. Likewise the panels could be of a different polygonal shape from the rectangular shape illustrated in Figures 10 to 13. If so, the bending of oblique edges will be carried out along a predetermined component intermediate

between directions X and Y, all with coordinated driving by the screws 26 and 28 (Figures 1 to 3).

Reference will now be made to Figures 14 to 35 to illustrate another method that can be carried out on a machine according to the invention, for the bending of external and internal edges of a slotted panel P_3, intended as a door or window frame, for example.

In Figures 14 to 35 the clamps are again marked 34, the slide is again marked 24 and the bending unit is again marked 54.

The panel P_3, which is of rectangular shape, has four external edges to be bent F_1, F_2, F_3, F_4, and four internal edges also requiring to be bent, G_1, G_2, G_3, G_4.

Once again in the case of Figures 14 to 35 the panel P_3 has been put through a preliminary cutting operation in order to form a central slot bounded by the edges G_1, G_2, G_3, G_4.

As will be observed, in the case illustrated the clamps 34 initially grip the edge F_3.

In much the same way as was described earlier with reference to Figures 10 to 13, while the clamps 34 are gripping the edge F_3, the following bends are formed in succession by the unit 54:

Figures 14 and 15: external edge F_1 is bent;

Figures 16 and 17: internal edge G_3 is bent;

Figure 18: unit 54 rotates through 180°;

Figures 19 and 20: internal edge G_1 is bent;

Figure 21: unit 54 is rotated through 90°;

Figures 22 and 23: internal edge G_2 is bent;

Figures 24 and 25: external edge F_4 is bent;

Figure 26: unit 54 is rotated through 180°;

Figures 27 and 28: internal edge G_4 is bent;

Figures 29 and 30: external edge F_2 is bent;

Figure 31: unit 54 is rotated through 90° and returned

to a position in which the two blankholders 64, 68 (Figures 4 to 6) grip the panel P_3 centrally between the already bent edges F_1 and G_1;

Figure 32: unit 54 and panel P_3 are rotated through 180° so as to present already-bent edge F_1 to the clamps 34;

Figure 33: clamps 34 grasp edge F_1 and blankholders 64, 68 are relaxed;

Figure 34: panel P_3 is moved to bring the unit 54 over the final edge F_3 to be bent; and

Figure 35: edge F_4 is progressively bent in accordance with the procedure described earlier.

As will be appreciated, in the operations shown in Figures 31, 32 and 33 the two blankholders 64, 68 (Figures 4 to 6) act as auxiliary gripping means substituting for the main gripping means represented by the clamps 34.

CLAIMS

1. Method for the production of sheet metal panels with at least one bent edge, in which the bend or bends in the panel are formed by means of a bending unit (54) having as a minimum, by way of tools, a pair of opposing blankholders (64, 68) and at least one blade (66) and one counterblade (70) which cooperate to define a bend line, in which the panel (P, P_1, P_3) to be bent is gripped and moved by gripping means (34) forming part of a manipulator (16) provided for the unit (54) and in which, in order to form bends, the relative movements of the tools (64, 66, 68, 70) and of the gripping means (34) are brought about in a coordinated way in order to form one or more programmed bends in the panel,

characterized in that the bending unit (54) uses a blade (66) and a counterblade (70) whose length (L), in the direction of the bend line, is less than the length of the bend or bends to be formed, and in that in order to form a bend, the movements of the tools (64, 66, 68, 70) and the relative movements of the unit (54) and of the gripping means (34) of the manipulator (16) are brought about in a coordinated way in order to execute the following cycle of consecutive operations:

I - while the blankholders (64, 68) are held apart from each other and the blade (66) and counterblade (70) are inactive, the panel (P, P_1, P_3) is held by the gripping means (34) and there is relative movement between the panel and the bending unit (54) leading to a relative position in which the panel is between the tools (64, 66, 68, 70), the line of the bend to be formed corresponds to the abovementioned bend line and the tools are situated on either side of an initial part (S_1) of the edge to be bent;

II - the panel (P, P_1, P_3) is clamped between the two blankholders (64, 68) and a first part of the bend is formed by the blade (66) and counterblade (70) with no

relative movement between the panel and the bending unit (54);

III - the two blankholders (64, 68) are moved apart and there is relative movement between the panel (P, P_1, P_3) and the bending unit (54) in the direction of the bend line for a distance approximately equal to or slightly less than the abovementioned length (L) of the blade (66) and of the counterblade (70);

IV - the panel (P, P_1, P_3) is clamped between the two blankholders (64, 68) and the next part of the bend (S_2, S_3, ... S_n) is formed by the blade (66) and counterblade (70);

V - steps III and IV are repeated as many times as is necessary to continue the bend as far as the final end of the edge that is being bent;

VI - the two blankholders (64, 68) are moved apart and there is relative movement between the panel (P, P_1, P_3) and the bending unit (54) so as to remove the panel or to commence step I in relation to another bend on the same panel.

2. Method according to Claim 1, characterized in that in steps III and IV and in their repetitions, a partial bend is formed in which the dihedral angle is smaller than the desired final dihedral angle and, when the partial bend has been completed at the end of the repetition of steps III and IV, similar steps are carried out with a relative movement between the panel (P, P_1, P_3) and the bending unit (54) in the reverse direction (Y_2) as far as the abovementioned initial part (S_1) of step I, in order to increase the dihedral angle of the bend and if possible to achieve the desired final dihedral angle, and in that if the desired final angle is not achieved as many similar steps in one direction (Y_1) and in the other (Y_2) as are necessary are carried out in order to achieve the desired final angle.

3. Method according to Claim 1 or 2, characterized in that in order to execute the bending of at least one edge situated inside the perimeter of a sheet (S) or panel (P_1, P_3) of sheet metal, the panel or sheet is put through a preliminary cutting operation in order to form this internal edge (E_1, E_2, E_3, E_4; G_1, G_2, G_3, G_4), and in that during steps I, III and IV and their repetitions, the gripping means (34) hold the panel at one or more points that will not interfere with the internal edge that is being bent.

4. Method according to Claim 3, characterized in that in order to execute the bending of at least two consecutive nonaligned edges (E_1, E_2, E_3, E_4) situated inside the perimeter of the sheet (S), the sheet (S) is put through a preliminary cutting operation in order to form these internal edges and at each point between the adjacent ends of these edges a bridge of metal (B) is left, after which each edge is bent in accordance with the steps of Claim 1 or 2, the transition between the steps of bending one edge and those of bending the next edge comprising an intermediate step of relative rotation of the sheet (S) and of the bending unit (54) through an angle equal to the angle between the abovementioned internal edges, and after all the bends have been formed the abovementioned bridges (B) are broken or removed.

5. Method according to Claim 1 or 2, for the production of panels (P_1, P_2) having a polygonal outline with a bent edge (E_1, E_2, E_3, E_4) corresponding to at least one of the sides of the polygon, characterized in that a metal sheet (S) is put through a preliminary cutting operation in order to form, inside the outline of the sheet, a cut design of a polygonal shape corresponding to that of the panel to be produced and leaving bridges of metal (B) connecting the outline of the sheet (S) to at least some corners of the polygonal shape, after which the edge or edges to be bent

(E_1, E_2, E_3, E_4) are bent in accordance with the steps of Claim 1 or 2, while the gripping means (54) hold one or more points of the sheet (S) outside the outline of the polygonal shape, the transition between the steps of bending one edge and the optional steps of bending a consecutive edge comprising an intermediate step of relative rotation of the sheet (S) and of the bending unit (54) through an angle equal to the angle between the abovementioned internal edges, with the abovementioned bridges (B) being broken or removed at the end.

6. Method according to Claim 5, characterized in that a plurality of consecutive panels (P_1, P_2) of polygonal shape are formed in the abovementioned way from a metal sheet (S).

7. Method according to any one of the previous claims, characterized in that in the abovementioned steps I, II and IV, the unit (54) is kept stationary and the panel (P_1, P_3) or sheet (S) is moved in a straight line and, if two consecutive nonaligned bends are to be formed, the unit is rotated through the angle formed by these two bends.

8. Method according to Claim 7, characterized in that the main gripping means consist of one or more clamps (34) that hold the panel (P_3) along an external edge (F_3) and, for the purpose of bending this external edge, the blankholders (64, 68) of the bending unit (54) are used as auxiliary gripping means in order to perform the succeeding steps of:

- gripping of the panel (P_3) by the blankholders (58, 64) and releasing of the panel (P_3) by the clamp or clamps (34);
- relative rotation of the bending unit (54) and clamp or clamps (34) about an axis normal to the panel and relative movement of these to bring another edge (F_1) of the panel (P_3) between the clamp or clamps (34); and
- gripping of the panel (P_3) by the clamp or clamps (34) along said other edge (F_1) and releasing of the panel (P_3)

by the blankholders (58, 64);

and in that in order to fold this edge the steps of Claim 1 or 2 are then carried out.

9. Method according to any one of the previous claims, characterized in that the relative movements of the tools (64, 66, 68, 70) and of the gripping means (34) are brought about in a coordinated way by a numerical- control system.

10. Machine for the production of sheet metal panels with at least one bent edge, comprising:

- a bending unit (54) having as a minimum, by way of tools, a pair of opposing blankholders (64, 68) and at least one blade (66) and one counterblade (70) which cooperate to define a bend line;
- a manipulator (16) provided for the unit and having means (34) for gripping a metal sheet from which the panel (P, P_1, P_3) is to be made, and
- means for bringing about in a coordinated way the relative movements of the tools (64, 66, 68, 70) and of the gripping means (34) in order to form one or more programmed bends along at least one edge of the panel,

characterized in that

- the bending unit (54) and the gripping means (34) are moved relative to each other, by drive means, along at least two axes (X, Y) contained in the plane of the panel (P, P_1, P_3) to be bent and one of which is parallel with the bend line, and
- the blade (66) and counterblade (70) are of such a length (L) in the direction of the bend line, and the coordinated drive means are so arranged as to execute the following cycle of consecutive operations:

I - while the blankholders (64, 68) are held apart from each other and the blade (66) and counterblade (70) are inactive, the panel (P, P_1, P_3) is held by the gripping means (34) and there is relative movement between the panel (P, P_1, P_3) and the bending unit (54) leading to a relative

position in which the panel (P, P_1, P_3) is between the tools (64, 66, 68, 70), the line of the bend to be formed corresponds to the abovementioned bend line and the tools are situated on either side of an initial part (S_1) of the edge to be bent;

II - the panel (P, P_1, P_3) is clamped between the two blankholders (64, 68) and a first part of the bend is formed by the blade (66) and counterblade (70) with no relative movement between the panel and the bending unit (54);

III - the two blankholders (58, 64) are moved apart and there is relative movement between the panel (P, P_1, P_3) and the bending unit (54) in the direction of the bend line for a distance approximately equal to or slightly less than the abovementioned length (L) of the blade and of the counterblade;

IV - the panel is clamped between the two blankholders and the next part of the bend is formed by the blade (66) and counterblade (70);

V - steps III and IV are repeated as many times as is necessary to continue the bend as far as the final end of the edge that is being bent;

VI - the two blankholders (64, 68) are moved apart and there is relative movement between the panel (P, P_1, P_3) and the bending unit (54) so as to remove the panel or to commence step I in relation to another bend on the same panel.

11. Machine according to Claim 10, characterized in that the blade (66) or each blade has an active edge (84) that is beveled at at least one initial end (86) in order to join up an already-formed part of the bend and a part of the bend that is yet to be formed.

12. Machine according to Claim 11, characterized in that the abovementioned coordinated drive means are so arranged as to form, in steps III and IV and in their repetitions,

a partial bend in which the dihedral angle is smaller than the desired final dihedral angle and, when the partial bend has been completed at the end of the repetition of steps III and IV, to carry out similar steps with a relative movement between the panel (P, P_1, P_3) and the bending unit (54) in the reverse direction (Y_2) as far as the abovementioned initial part (S_1) of step I, in order to increase the dihedral angle of the bend and if possible to achieve the desired final dihedral angle, and so as to carry out as many similar steps in one direction (Y_1) and in the other (Y_2) as are necessary in order to achieve the desired final angle.

13. Machine according to Claim 12, characterized in that the blade (66) or each blade has an active edge (84) that is beveled at both ends (86) in order to join up a formed part of the bend and a part of the bend that is yet to be formed.

14. Machine according to any one of Claims 10 to 13, characterized in that the bending unit (54) is stationary and the gripping means (34) are movable in at least one direction (Y) parallel with the bend line and in a direction (X) perpendicular to this line.

15. Machine according to Claim 14, characterized in that the gripping means (34) are part of a manipulator (16) that comprises:

- a fixed bed (10),
- a first driven slide (22) adapted to move on the bed towards and away from the bending unit (54),
- a second driven slide (24) adapted to move on the first slide (22) transversely to the direction of movement of the first slide, and
- at least one gripping clamp (34) mounted on the second slide (24) for gripping the panel (P, P_1, P_2) .

16. Machine according to Claim 15, characterized in that the two slides (22, 24) are moved by respective screw-and-

nut-type motorized drives (26, 28).

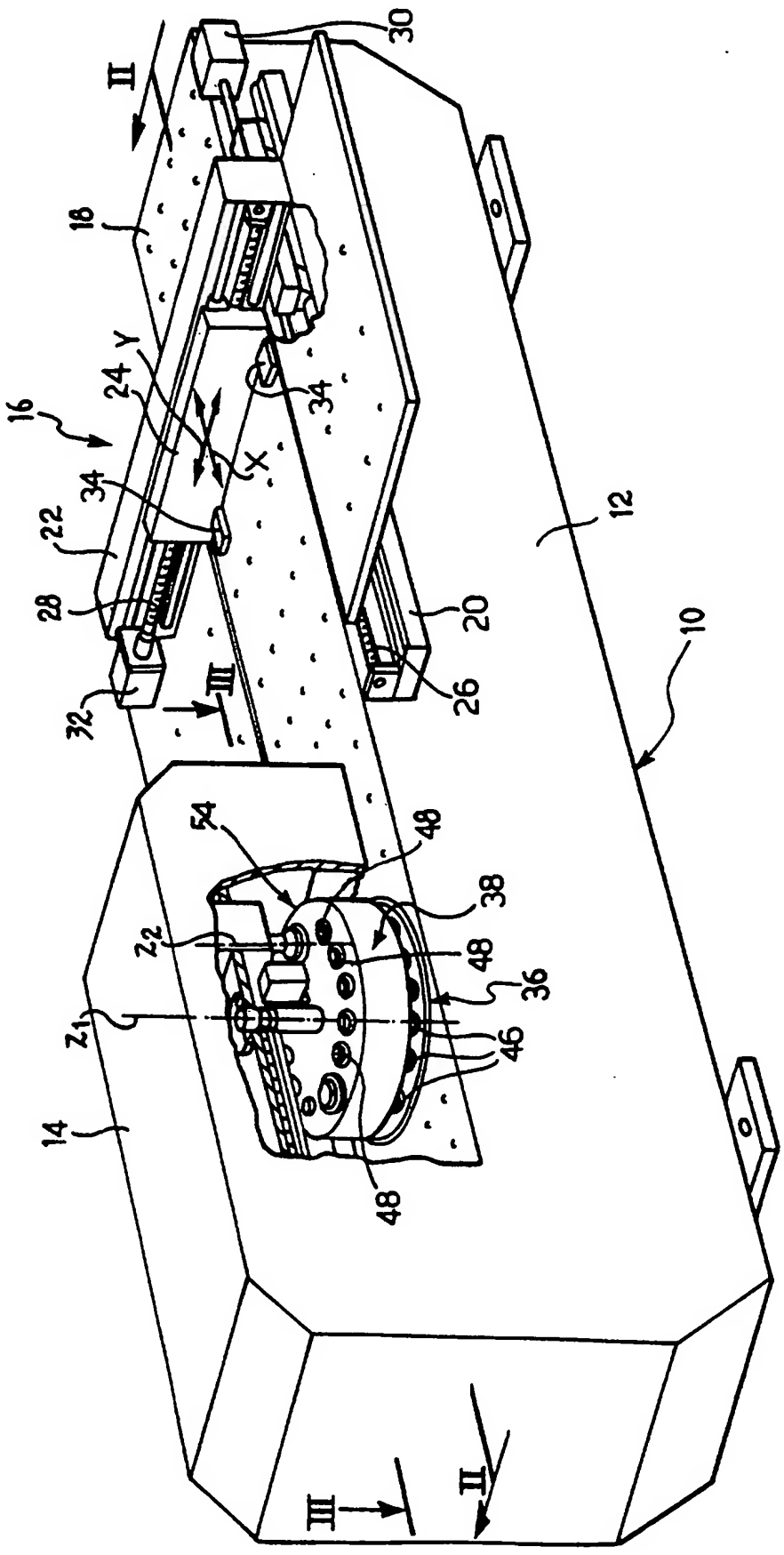
17. Machine according to any one of the previous claims, characterized in that it comprises a structure carrying two opposing toolholder blocks (56, 58), between which the panel (P, P_1, P_3) is inserted, that are able to move relatively, one towards and away from the other, under the control of the coordinated drive means and that each incorporate one of the blankholders (64, 68) and at least one blade (66) or one counterblade (70).

18. Machine according to Claim 17, characterized in that each of the blocks (56, 58) can be rotated, in its abovementioned structure, about an axis (Z_2) normal to the plane of the panel (P, P_1, P_3) that is to bent, and in that the two blocks are driven and orientated as one about this normal axis (Z_2), by the coordinated drive means, for the purpose of bending edges that are not aligned and not parallel with each other.

19. Machine according to Claim 17, characterized in that it comprises a basically C-shaped fixed frame (10) with two opposing parts (12, 14) integral with each other and spaced from each other, in that each frame part supports a respective turret (36, 38), the two turrets being spaced from each other and rotatable as one about a common axis (Z_1) normal to the plane of a panel (P, P_1, P_3) inserted between the two parts (12, 14) of the frame, in that each of the turrets (36, 38) has a ring of seats each aligned with the seats of the other turret in a circle (C) concentric with the axis of rotation (Z_1) of the turrets, in that in at least one pair of aligned seats, one seat contains a fixed toolholder block (56) and the other a movable toolholder block (58), one of which blocks incorporates one of the blankholders (64, 68) and the other at least one blade (66) or counterblade (70), and in that in at least some of the other pairs of aligned seats, one seat contains a die (46) and the other a cooperating punch

(48), the die or dies (46) being located in the turret (36) containing the fixed toolholder block (56) while the punch or punches (48) are located in the turret (36) containing the movable toolholder block (58), in that the punch or punches (48) and the movable toolholder block (58) can each move along their own axes parallel with the axis of rotation (Z_1) of the turrets, and in that that frame part (14) which supports the turret (38) containing the punch or punches (48) and the movable toolholder block (58) supports a ram (50) which is selectively controlled so as to act selectively on the punch or punches (48) or on the movable toolholder block (58) when and as these are in alignment with the ram (50) following a corresponding orientation of the turrets (36, 38) about their axis of rotation (Z_1).

20. Machine according to Claim 19, characterized in that the two toolholder blocks (56, 58) are rotatable in their seats about a common axis (Z_2) which coincides with the axis of movement of the movable block (58) and each turret (36, 38) is provided with means (76, 78) for rotating the blocks (56, 58) as one about their axis (Z_2) for the purpose of bending edges that are not aligned and not parallel with each other in the panel (P, P_1, P_3) inserted between the two turrets (36, 38).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Y
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16
X
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36
Z_1
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14
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III
II

FIG. 1

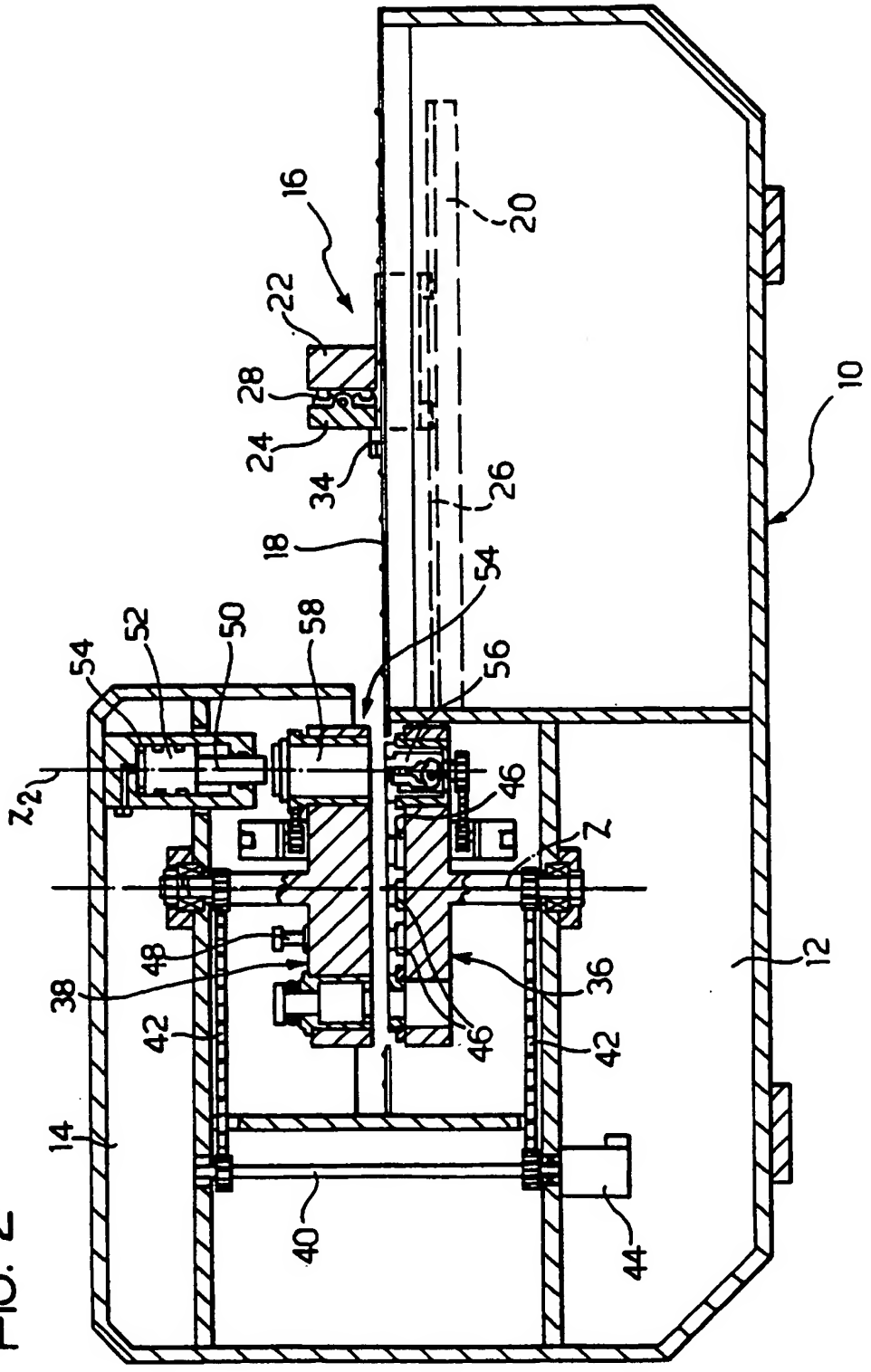
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FIG. 2

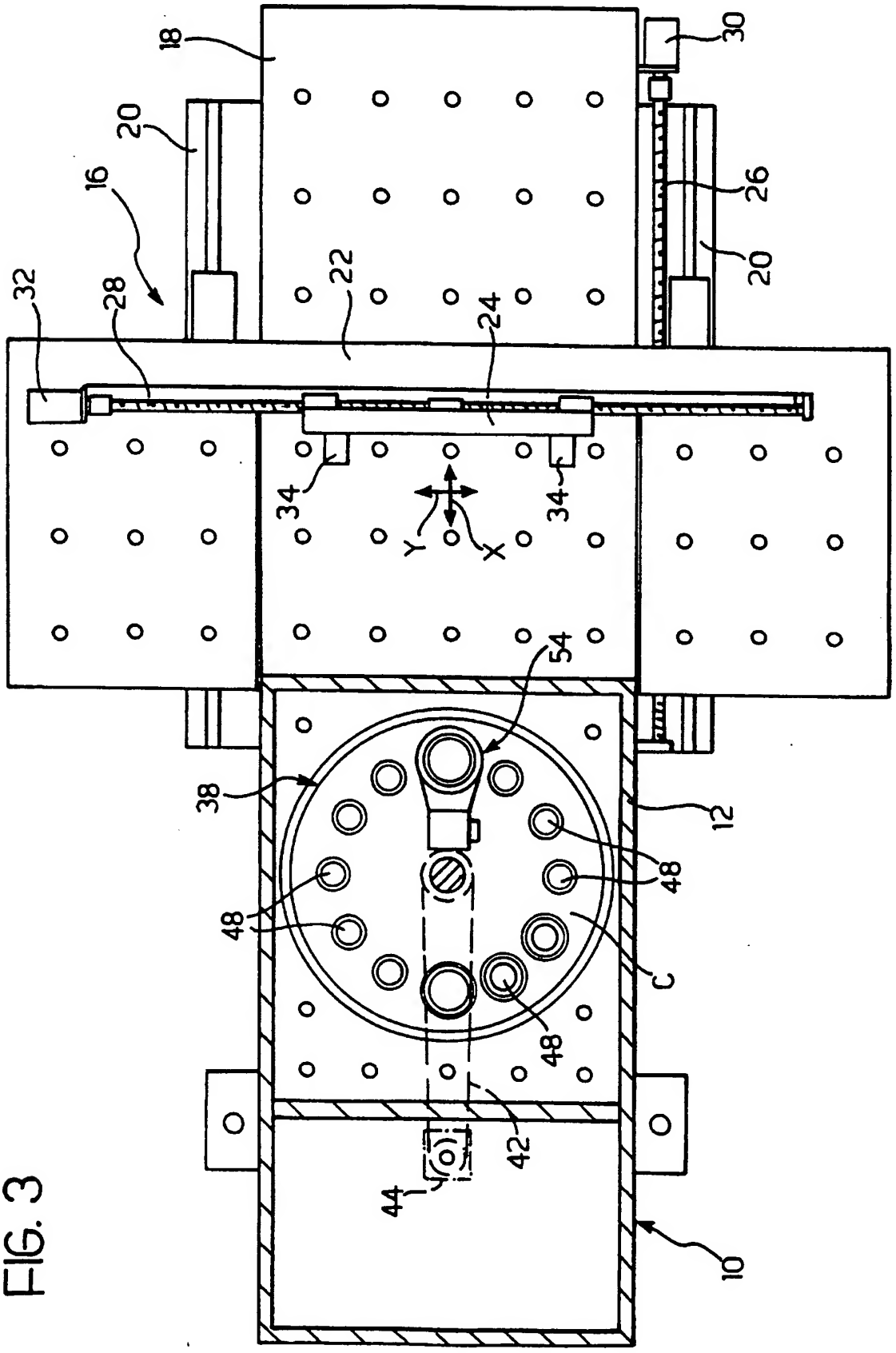

FIG. 3

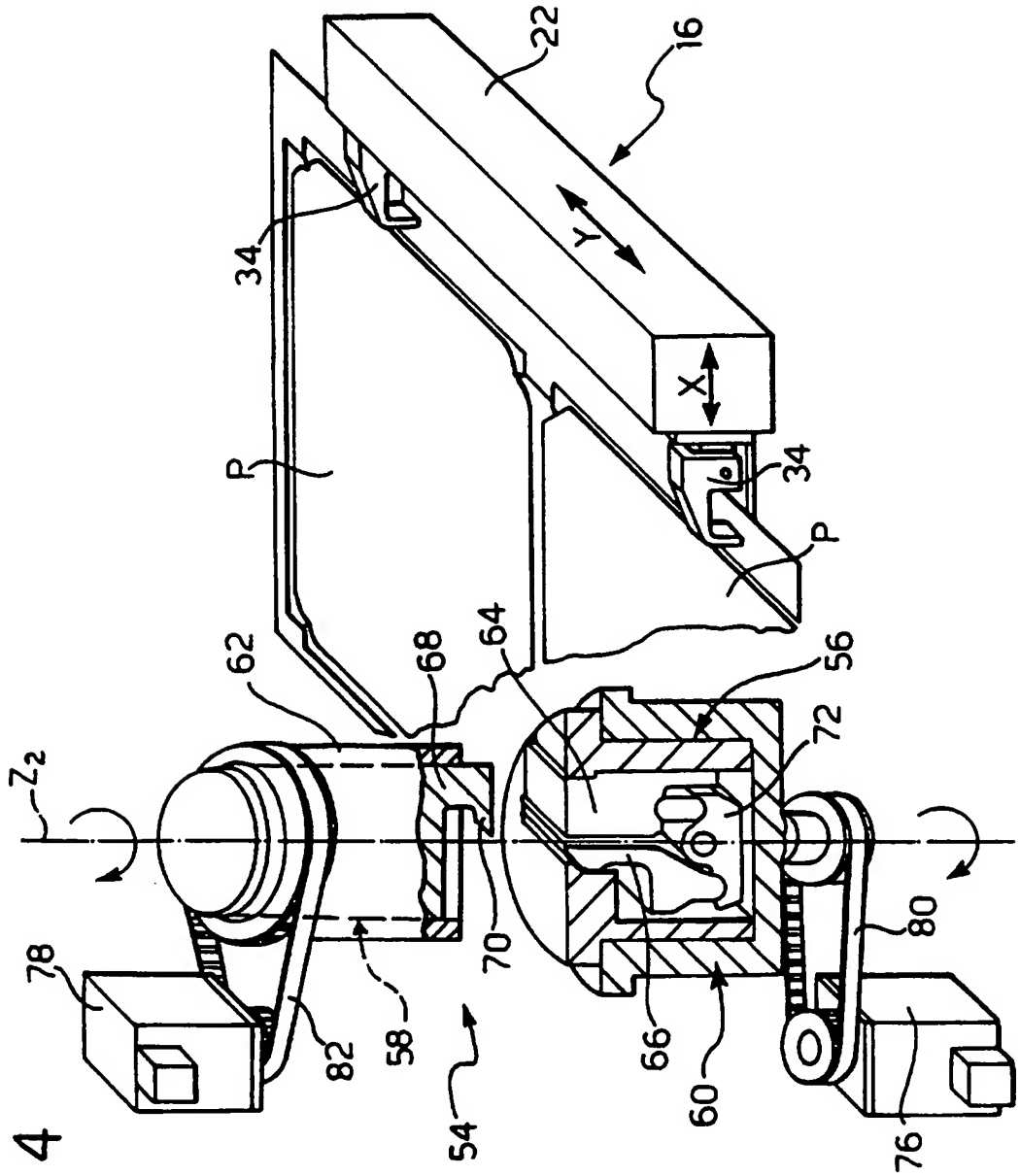

FIG. 4

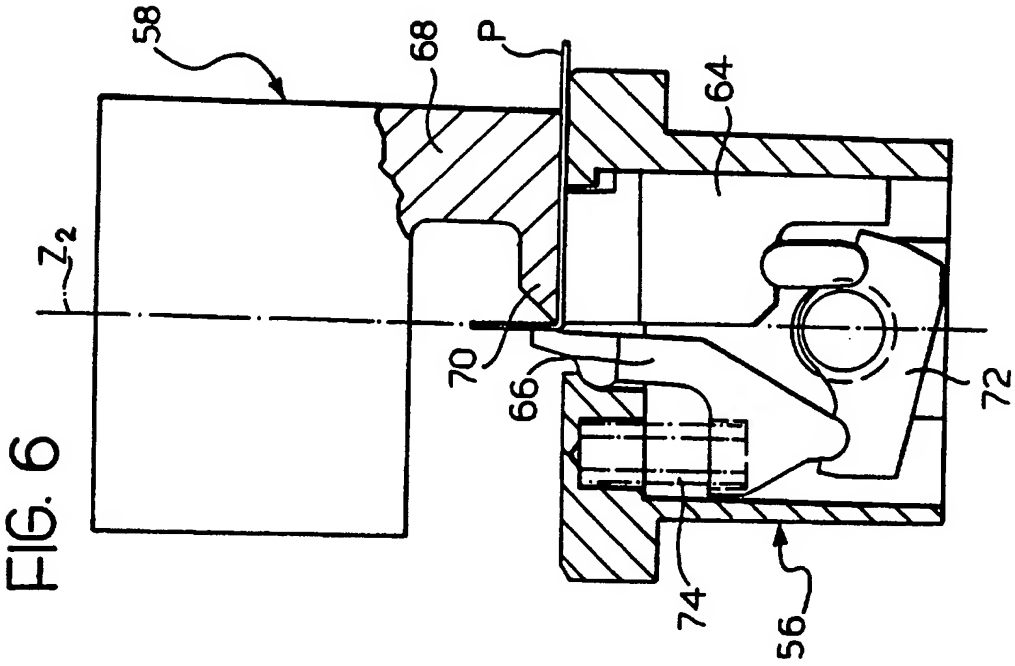

FIG. 6

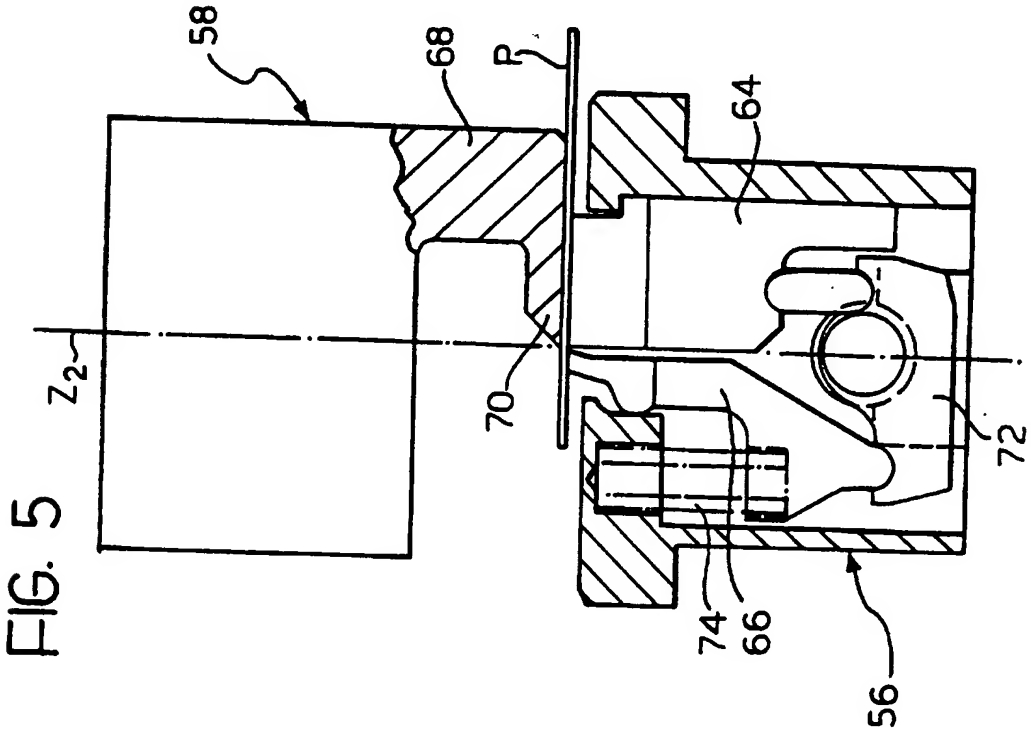

FIG. 5

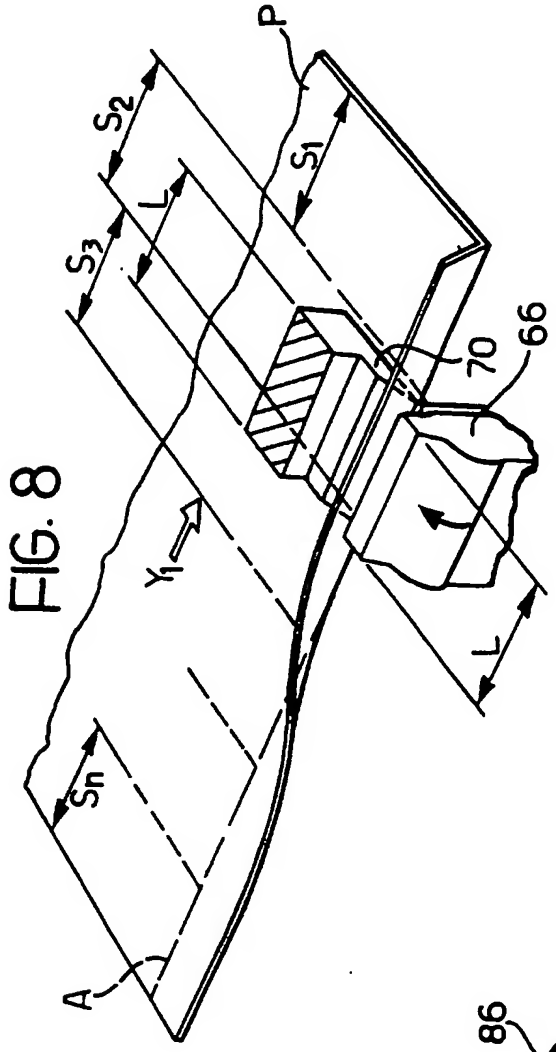

FIG. 8

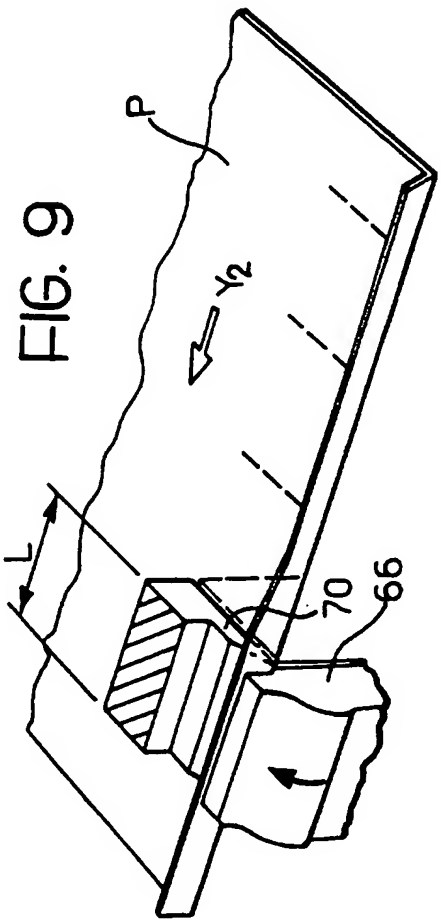

FIG. 9

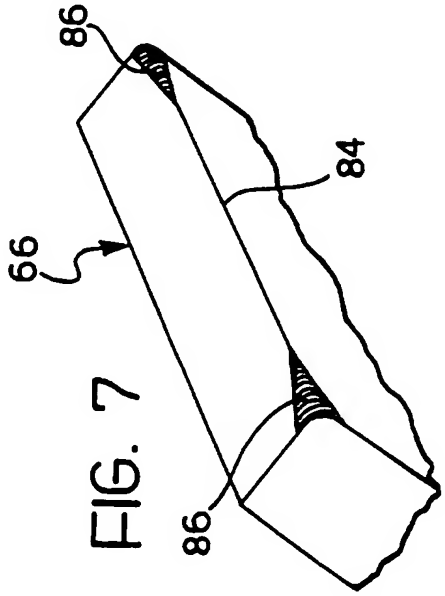

FIG. 7

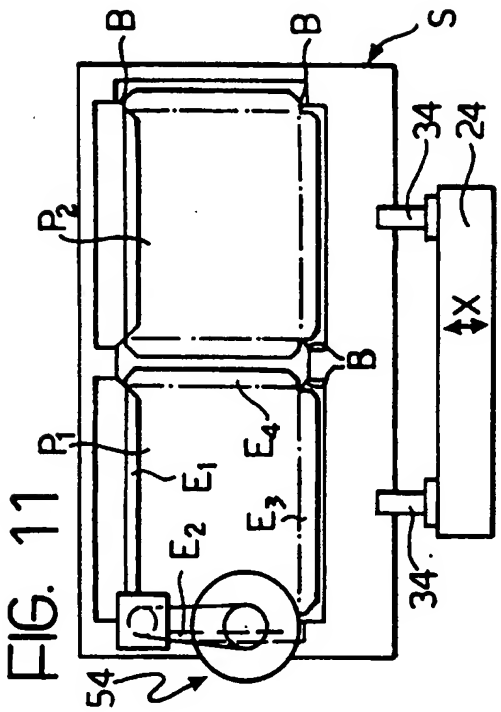

FIG. 11

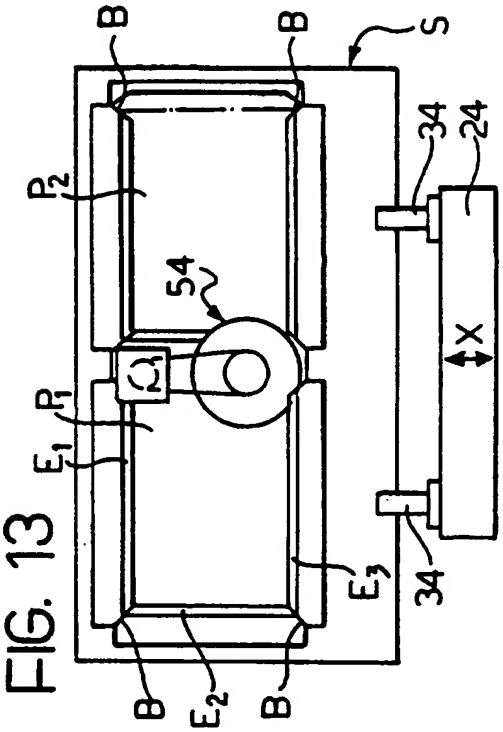

FIG. 13

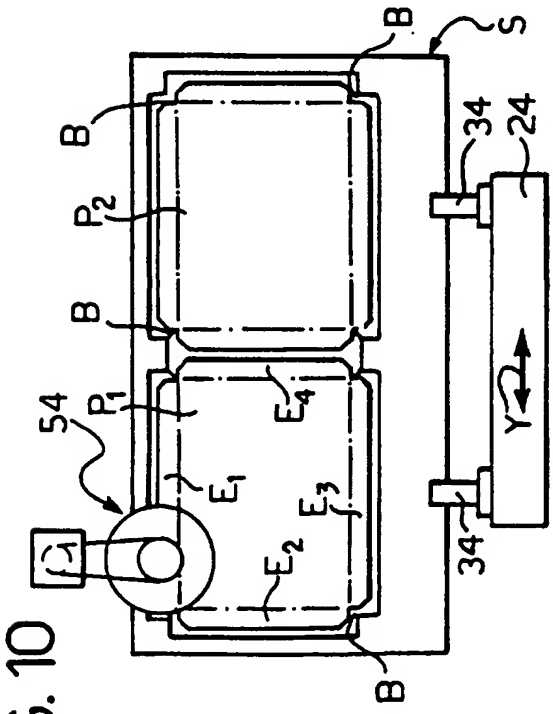

FIG. 10

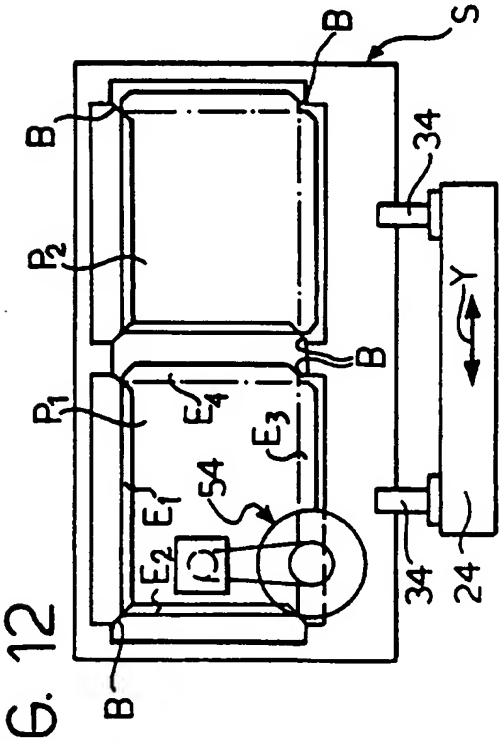

FIG. 12

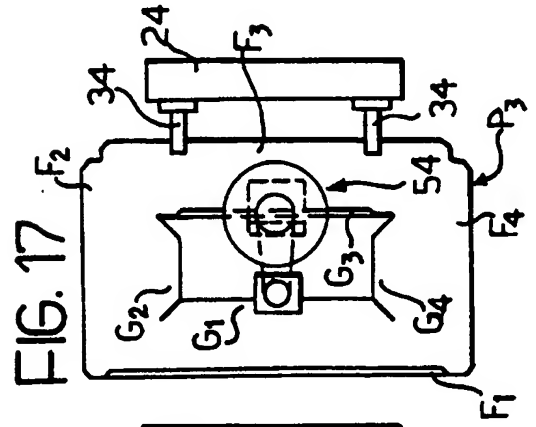

FIG. 17

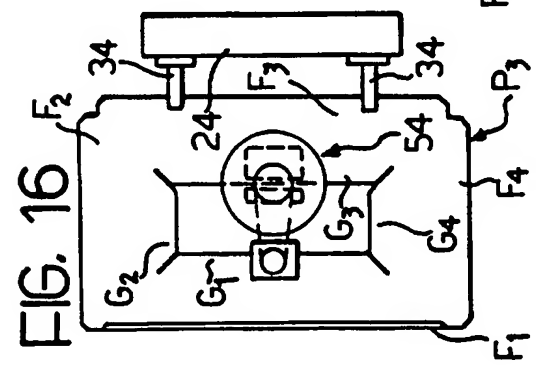

FIG. 16

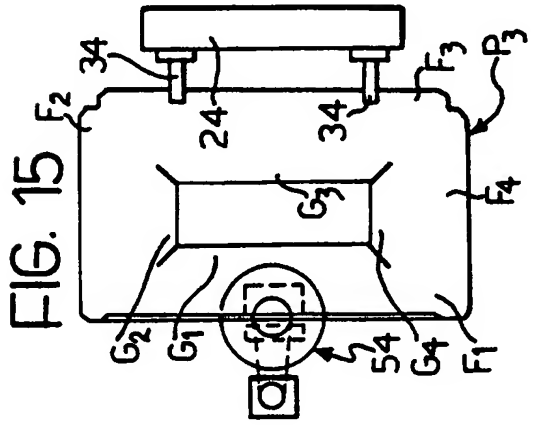

FIG. 15

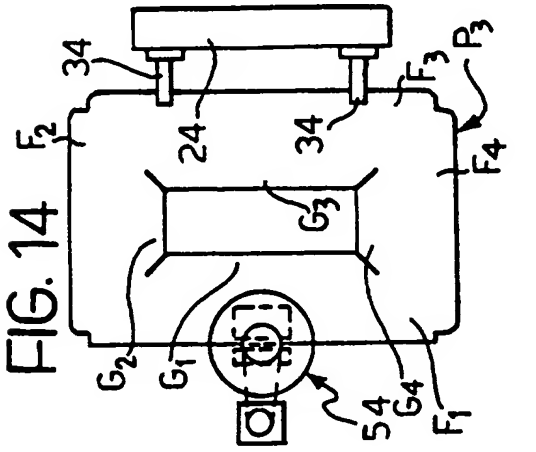

FIG. 14

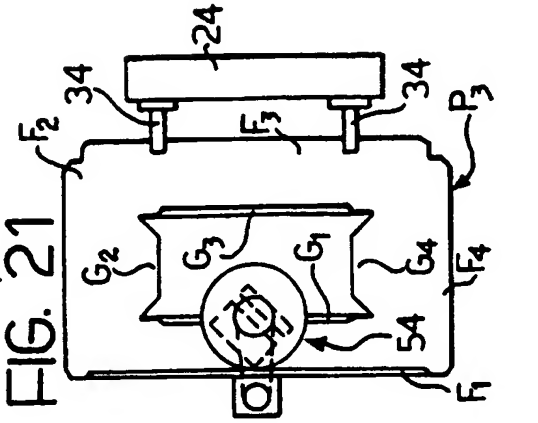

FIG. 21

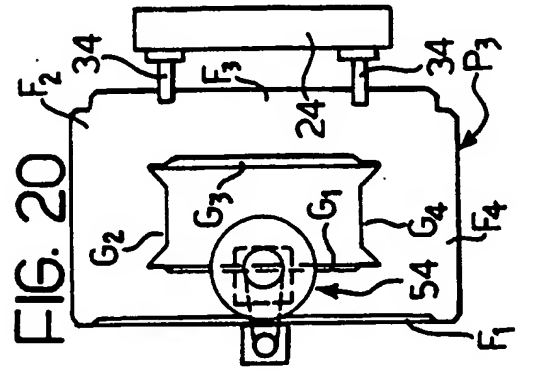

FIG. 20

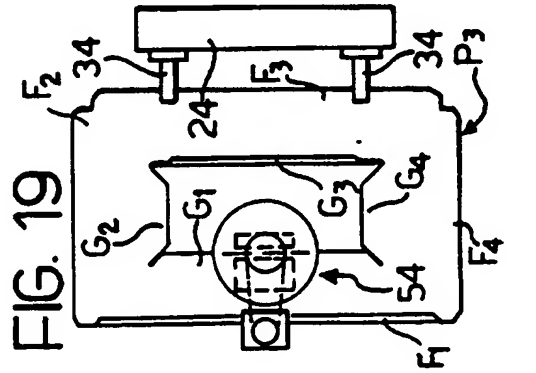

FIG. 19

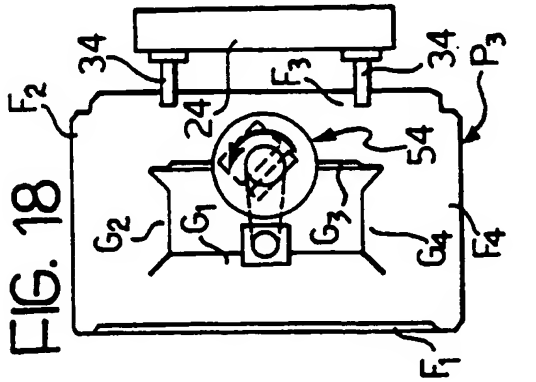

FIG. 18

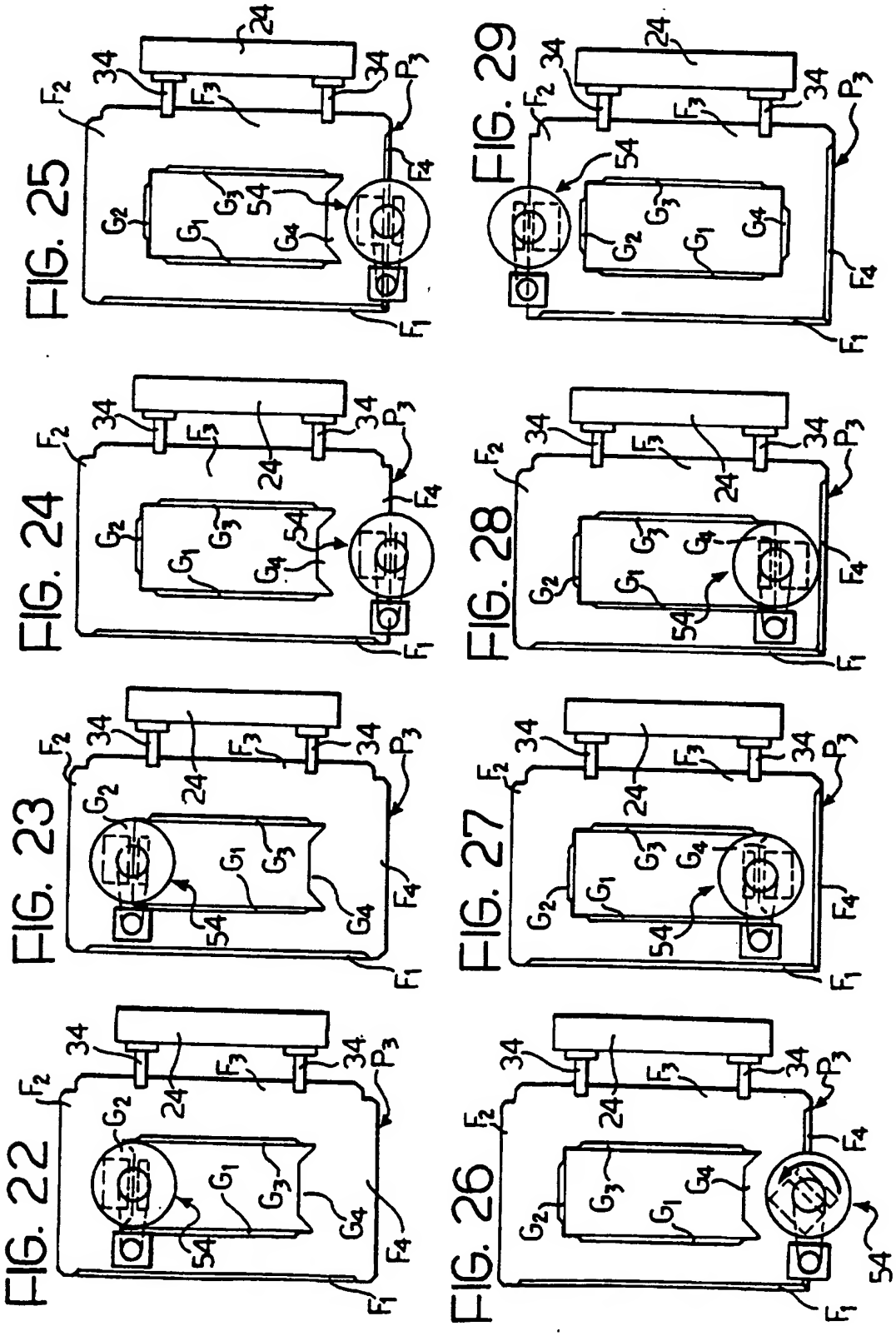
FIG. 25
FIG. 29
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FIG. 27
FIG. 22
FIG. 26
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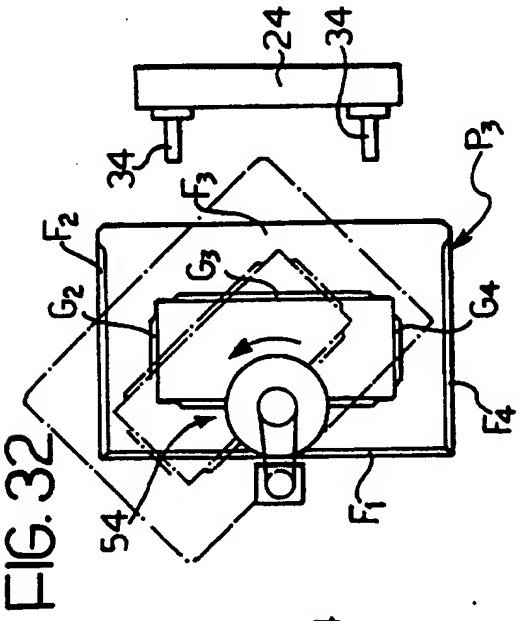

FIG. 32

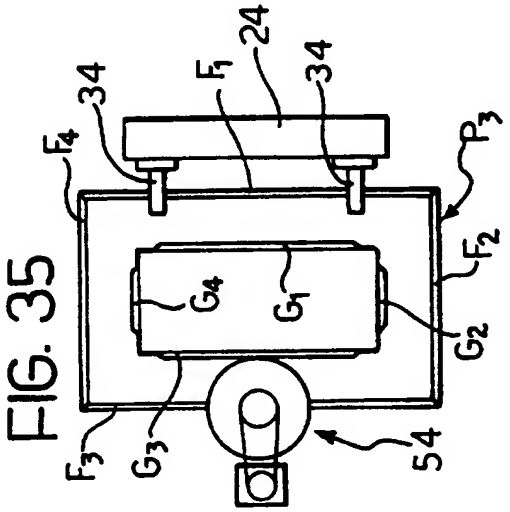

FIG. 35

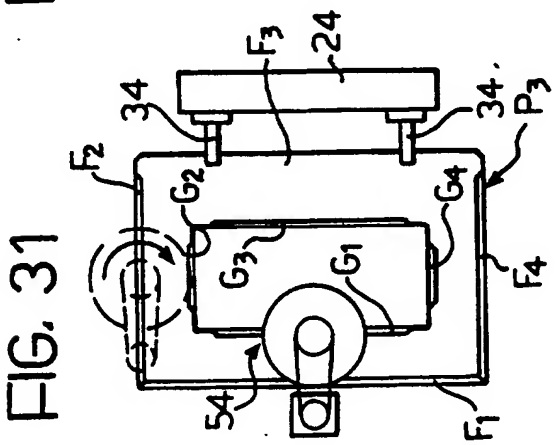

FIG. 31

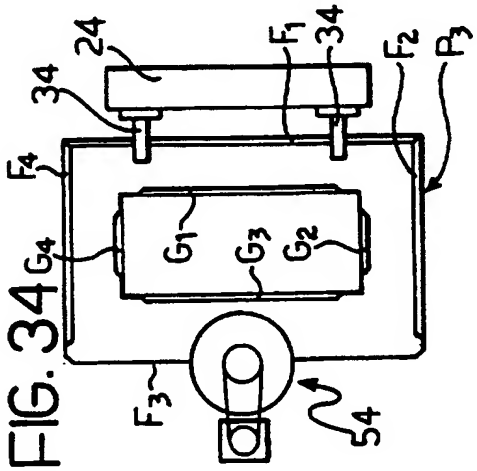

FIG. 34

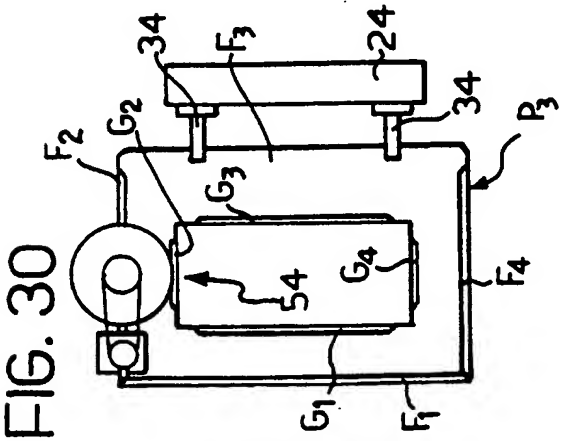

FIG. 30

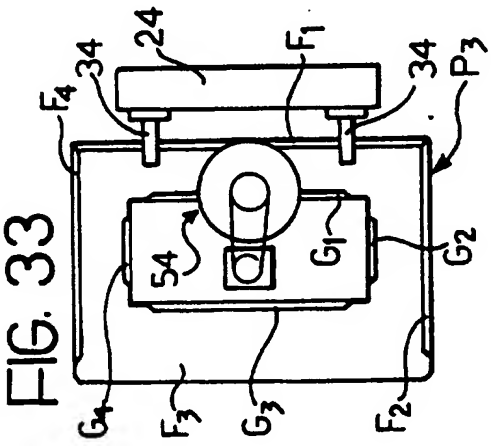

FIG. 33

INTERNATIONAL SEARCH REPORT

Interna J Application No
PCT/EP 96/00436

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B21D19/08 B21D5/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B21D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US,A,5 367 770 (MCCAUGHEY JOHN F) 29 November 1994	1,10
A	see figures 5,6,8	3-5,7,9, 18,20
A	EP,A,0 555 604 (AMADA CO LTD ;AMADA MANUFACTURING AMERICA IN (US)) 18 August 1993 see figures 11-18	1,14-16, 19
A	DE,C,740 600 (WEINGARTEN) 25 October 1943 see the whole document	2,11,12
A	FR,A,855 306 (CONSTRUCTIONS AÉRONAUTIQUES) 8 May 1940	

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☒ Patent family members are listed in annex.

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"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
29 May 1996	12.06.96

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+ 31-70) 340-3016	Ris, M

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Interna al Application No
PCT/EP 96/00436

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A-5367770	29-11-94	NONE	
EP-A-0555604	18-08-93	US-A- 5177843	12-01-93
		US-A- 5184498	09-02-93
		CA-A- 2085545	17-06-93
		EP-A- 0694347	31-01-96
		JP-A- 5277584	26-10-93
DE-C-740600		NONE	
FR-A-855306	08-05-40	NONE	

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